Structural Accessibility for Urban Policy: The case of Greater Oporto

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Abstract

There is a general recognition of the need for a holistic approach to urban planning and policy making. The lack of policy integration is jeopardizing the quality of life and the competitiveness of urban areas as well as their sustainable development. With regard to sustainable travel behaviour (one of the key features of urban sustainability) urban policies are believed to require an integrated approach to land use and transport planning.

This paper presents the results of an application to Greater Oporto of the Structural Accessibility Layer (SAL) – a design support tool for integrated land use and transport policies based on the concept of structural accessibility. The local accessibility conditions and the resulting potential for sustainable mobility patterns are mapped and analysed. In addition, the SAL supported the design of policy recommendations. The results of this case study provide an adequate background for a more general discussion on the role of the accessibility concept in urban policy formulation.

Our research shows that the geographical representations of accessibility levels provide a new insight into mobility conditions for sustainability. Furthermore, the importance of accessibility measures for sustainable urban policies is rendered clear.

Keywords: Structural Accessibility; Urban Policy; Integrated Approach; Design Support Tool

1 Introduction

Current social and political concerns with environmental issues, social equity, quality of life and sustainability have been responsible for a growing recognition of the need for a holistic approach to urban policy. With regard to sustainable travel behaviour urban policies are believed to require an integrated approach to land use and transport planning.

Transport Policy has traditionally been responsible for the management of mobility patterns. Originally, transport policy aimed at providing an answer to travel needs by offering the necessary transport infrastructure and services – the 'predict and provide' paradigm. As part of the new requirements for sustainable development, there has been a general recognition of the need to manage the demand side of travel. The new 'predict and prevent' paradigm requires a broader approach to mobility management, which clearly surpasses the boundaries of traditional transport planning.

From the variety of constraints and motivations influencing travel behaviour, land use and transport systems provide the baseline exogenous conditions steering travel patterns. Land use raises the need to move in order to participate in disperse urban activities, while the transport system offers the conditions to satisfy these mobility needs. Thus, mobility patterns are constrained by the land use and transport system (or urban structure). The choice of specific travel patterns within the range of potential mobility patterns is further influenced by other aspects, such as socio-economic and demographic characteristics. Nevertheless, if the urban structure does not provide the necessary conditions to enable mobility to be sustainable then other policy actions on socio-economic and demographic characteristics have only limited potential.

Considering that land use and transport systems have a mutual influence (besides their influence on mobility patterns), there is a need for a careful combination of policies to reinforce each other avoiding adverse side-effects (Rodenburg *et al.*, 2002; 463).

Indeed, the need for the integration of land use and transport policies has been recognized by several authors (e.g. Banister, 1994a,b; ISIS, 1999; Wegner and Fürst, 1999; Halden, 2002; Stead, 2003; Cervero 2003). Integrated land use and transport policies can provide the necessary (albeit not sufficient) conditions for sustainable mobility patterns, without which complementary policy actions would have limited to no effect.

A study developed by NEA (2003), on the integration of public transport, suggests that higher levels of integration may increase efficiency and enable a better achievement of common objectives. Furthermore, Stead *et al.* (2003) state that 'there is an increasing recognition that inconsistent policies entail a higher risk of duplication, inefficient spending, a lower quality of service, difficulty in meeting goals, and, ultimately, of a reduced capacity to govern.' (Stead *et al.*, 2003; 16).

Nevertheless, in spite of clear theoretical and empirical evidences of interaction between land use and transport systems and of the broad political and academic recognition of the need to foster this integration, in practice, that is seldom carried out. One of the reasons for this fact is the lack of appropriate and readily available design support tools.

Several authors such as Halden *et al*. (2000), Bertolini *et al*. (2005) and Straatemeier (2006) believe that accessibility measures provide a useful framework for the design of integrated land use and transport policies. Accessibility measures are believed to adequately describe the link between transport and land use (Handy and Niemeire, 1997; Halden *et al*., 2000; Halden, 2002; Bertolini *et al*., 2005). Geurs and Wee (2004) argue that these measures are easy to interpret and operationalise. Finally, Straatemeier and Bertolini (2008) suggest that accessibility measures have the potential to deal with current limitations in the development of integrated land use and transport policies. They argue that accessibility has the potential to address a threefold need for; a common language between land use and transport, a link of transport planning to broader policy concerns and more emphasis on the policy design phase.

As a result, accessibility measures seem to provide a useful design support framework by shedding light on the sustainability of potential mobility enabled by land use and transport conditions.

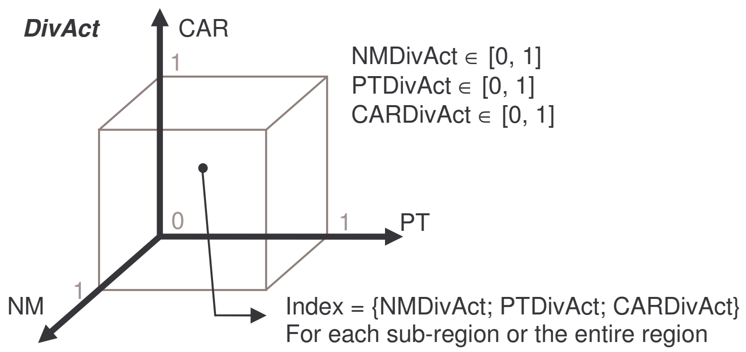
This paper presents the results of an integrated land use and transport policy approach for mobility management in Greater Oporto. After a brief presentation of the accessibility analysis tool, an application to Greater Oporto is presented, providing a discussion of current accessibility conditions as well as policy strategies and recommendations. The paper ends with a brief discussion of the potentials and usefulness of the accessibility concept for urban policies.

2 The Accessibility analysis tool

The Structural Accessibility Layer – SAL (Silva, 2008) is a design support tool based on the concept of structural accessibility. *Structural Accessibility* is defined as the *extent to which the land use and transport system enable individuals to reach different types of opportunities* (adapted from the accessibility concept presented by Geurs and Eck, 2001; 36). This definition reflects the spatial distribution of opportunities as well as the availability and service level of different transport modes. As defined by Silva (2008) the SAL includes two main accessibility-based indexes: the *diversity of activity index* (the accessibility measure) and the *comparative accessibility index* (the sustainability measure). These measures are geographically represented resorting to a high spatial disaggregation of analysis (at least at the census track level).

The diversity of activity index (DivAct) measures the accessibility level by each transport mode (non-motorized, public transport and the car). It is an aggregate measure of accessibility considering several mobility generating activities. The results of the diversity of activity index range from 0 (no accessible activities) to 1 (all considered activities are accessible) for each transport mode.

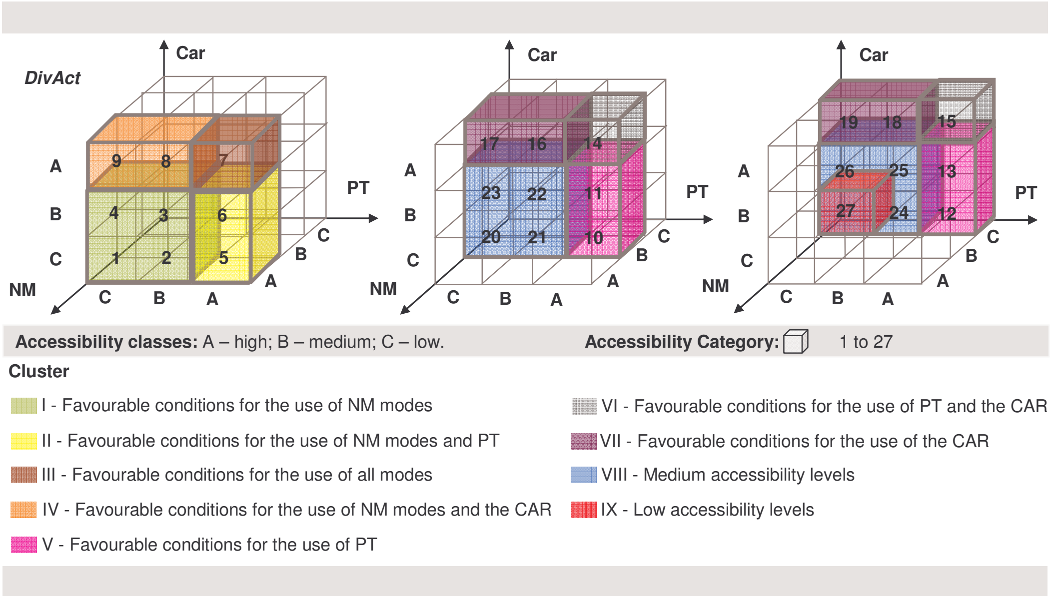
The comparative accessibility index uses the results of the first index to develop the comparative analysis of accessibilities by transport modes. This comparative index is then employed as a measure of sustainability of potential mobility patterns enabled by the baseline land use and transport conditions.



Source: Silva (2008)

Figure 1. Potential combinations of accessibility values by the three transport modes

The comparative accessibility index is made operational by the benchmarking cube, dividing the full range of accessibility levels by transport mode (figure 1) into categories and clusters. *Categories* represent *different conditions provided by the land use and transport system for travel behaviour*, concerning the potential choice of transport mode. These are a result of the division of the range of accessibility levels by each transport mode into 3 accessibility classes: high accessibility level, class A; medium accessibility level, class B; and low accessibility level, class C. The benchmarking cube is divided into 27 accessibility categories, grouped into 9 accessibility clusters (see figure 2). *Clusters* define *different levels of sustainability of potential mobility (regarding mode choice) enabled by the baseline land use and transport conditions*.



Source: Silva (2008)

Figure 2. The benchmarking cube

Clusters I to VII are a result of the grouping of accessibility categories representing land use and transport conditions favouring the use of the same transport mode (or modes). A transport mode is considered to be favoured by land use and transport conditions when it provides high accessibility levels. These clusters are ordered according to decreasing sustainability of mode choice favoured by the urban structure. Land use and transport conditions unable to provide high accessibility levels by any transport mode are grouped into clusters VIII and IX according to the highest level of accessibility provided. Contrarily to cluster numeration, the category number has no associated meaning besides of the position in the benchmarking cube.

The accessibility and sustainability measure, confer SAL a twofold capability: first, to analyse the present constraints of urban structure on the sustainability of potential mobility patterns; and second, to support the identification of operational policy options (contextualized by policy strategies) to enhance conditions for sustainable mobility patterns.

3 The case study application to the Greater Oporto

The region chosen for this case study comprises the core municipalities of the metropolitan area of Oporto (see Figure 3), the so-called Greater Oporto (GO). This region is located in the north-west of Portugal, encompassing the municipalities of Gondomar, Maia, Matosinhos, Oporto, Valongo and Vila Nova de Gaia, covering an area of about 560 km^2 (around 70% of the whole metropolitan area). Almost 1.1 million people live in this region (representing 90% of metropolitan population) with a workforce of around half a million.

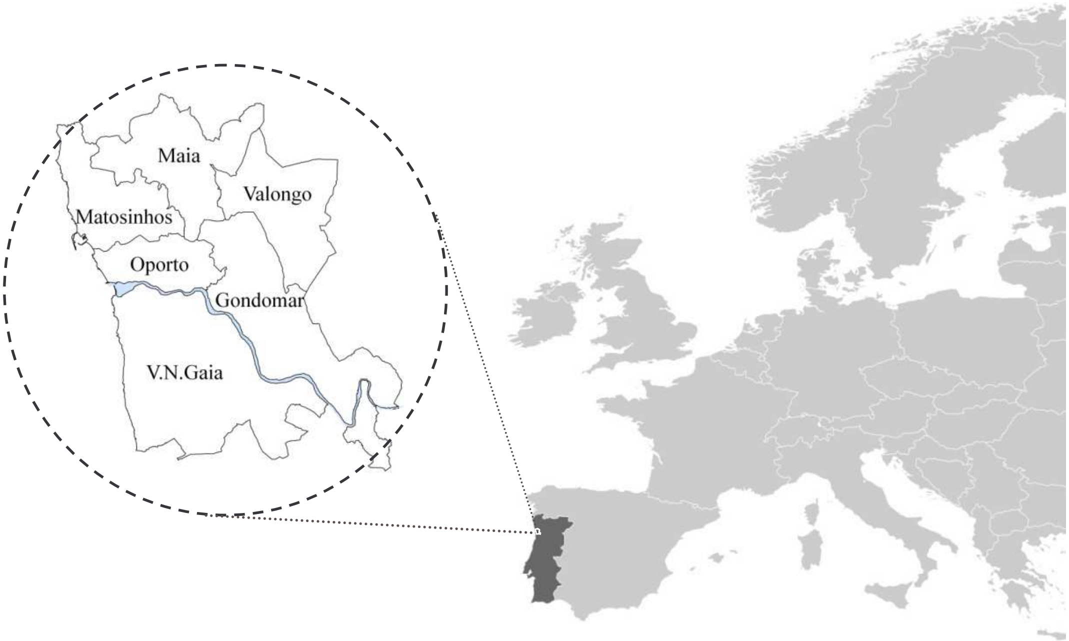
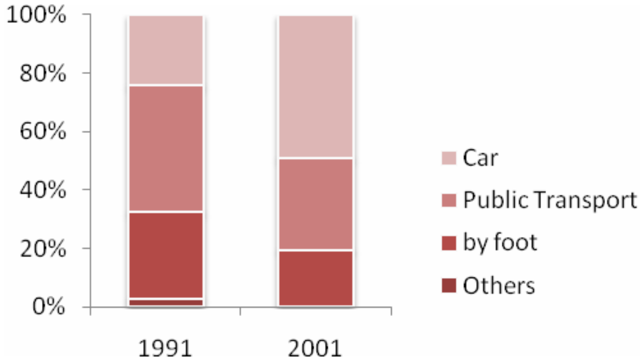


Figure 3. Europe / Portugal / GO / Municipalities

The transport system of the region has suffered important changes in recent years. The last two decades have been marked by the construction of several motorways, considerably reducing time-distance between places. As a result, it is fair to say that the case study region has a high road density. Public transport service has also suffered several changes in the last few years, with the introduction of a light-rail system (in 2002). A network oriented service is steadily replacing the established door-to-door service (including, for instance, pricing integration and network redesign), mainly among the different public transport operators. The area covered by the light-rail and the train system is, somehow, limited to the central area of the Oporto city and to a few radial corridors. The network oriented strategy followed by the public operators is more evident in the city of Oporto and to the North. The remaining study region is mainly served by private operators following the traditional door-to-door strategy.

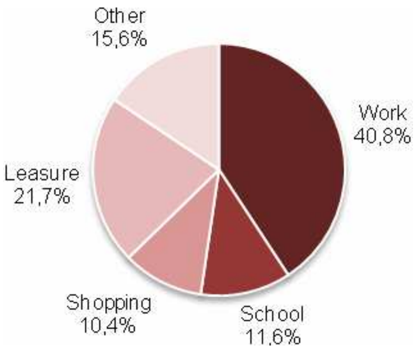
The study region has, currently, a high car use dependency. More than half of the trips engaged by its inhabitants are made by car. In only one decade public transport has largely been replaced by the car for work and school travel purposes (see Figure 4).



Data Source: INE (1991) and INE (2001)

Figure 4. GO's Modal split for the main modes in 1991 and 2001 (considering only work and school trips)

With regard to trip purpose, work trips are clearly dominant in the GO. In any case, these represent less than half of the total travel in the study region (see Figure 5). Other relevant activities for travel generation are leisure, school and shopping activities. Increasing complexity of travel behaviour is also visible in the significant importance of *other* trip purposes (more than 15%).



Source: INE 2000

Figure 5. Distribution of trip purposes

Travel behaviour in the metropolitan area of Oporto appears to be increasingly unsustainable. This phenomenon has several interrelated reasons such as; increasing distances between households and activities (related to decentralization of occupation, to the changes in the transport system and to the vicious cycle of car use), increasing complexity of travel needs (related to higher incomes and quality of life standards) and increasing car dependency (related to inefficiencies in public transport service and, also, to social status stigma). In this context, this metropolitan area provides an interesting case study to test the importance for urban policy formulation of an integrated approach to land use and transport planning.

3.1 SAL applied to Greater Oporto

For this case study the SAL used a highly disaggregated spatial analysis at the census track level. The diversity of activities as well as accessibility categories and clusters were defined for each census track (or sub-region) and for the entire region (using a weighted average by population). A broad list of activities was considered in the definition of travel generators including: employment, schools, leisure, shopping, healthcare and other activities. In total, 18 different activities were identified as relevant for travel generation. Accessibility limits were defined separately for each transport mode. For the car, activities were considered to be accessible within 30 minutes travel time. For non-motorized modes (which solely considered walking), a 20 minutes travel time limit was considered acceptable. With regard to public transport use, accessibility limits were considered to be more complex. In addition to a general time limit of 45 minutes, accessibility was also considered to be limited by the number of interchanges inside the public transport systems (maximum of 2), the increase of cost with interchange (no increase was considered acceptable), the walking distance at the interchange (maximum of 100m) and the waiting time at the interchange (maximum of 5 min). Mobility conditions in each transport system were calibrated based on average travel speed values for walking, for each public transport route and for road driving speed (taking into consideration congestion level and road hierarchy).

Finally, accessibility classes, dividing the benchmarking cube, were considered to be defined for the following values of the diversity of activity index:

- Class A (high accessibility): [0.85; 1]
- Class B (medium accessibility): [0.5; 0.85[
- Class C (low accessibility): [0; 0.5[

3.2 Current Accessibility conditions

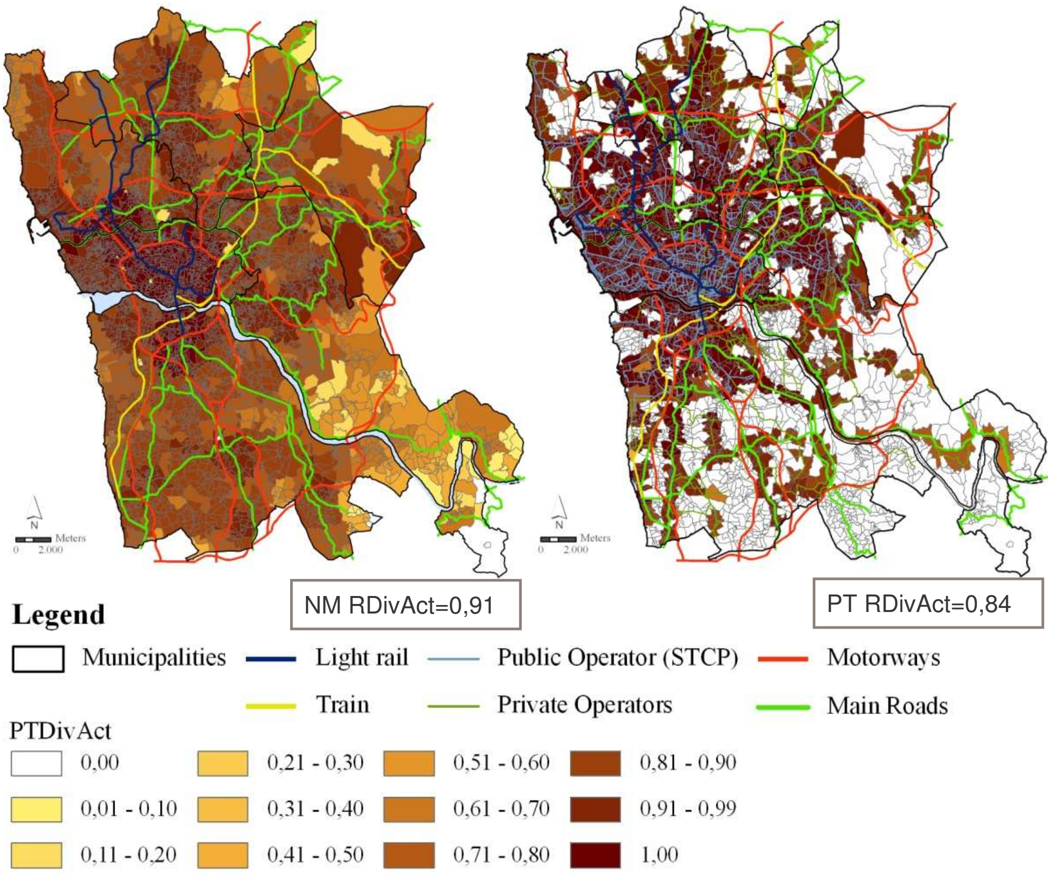
Current accessibility conditions in the study region are summarized in the following maps. Figure 6 represents small scale variations of accessibility conditions by non-motorized modes and by public transport. Given the homogeneity of the car accessibility map, its representation was considered unnecessary (in this respect, almost the entire study region presents the maximum value for the diversity of activity index). Figure 7 presents the results of the comparative accessibility index (for both, categories and clusters).

Table 1. Accessibility classes for each transport mode by area and by population

	Analysis by Area (% of 563km^2)			**Analysis by Population (% of 1.089.118 inhabitants)**		
	NM	**PT**	**CAR**	**NM**	**PT**	**CAR**
A	43,5%	47,8%	100,0%	77,6%	83,4%	100,0%
DivAct=1	*7,3%*	*31,3%*	*86,5%*	*25,2%*	*71,2%*	*98,1%*
B	48,6%	4,0%	0,0%	21,3%	1,7%	0,0%
C	7,9%	48,2%	0,0%	1,1%	15,0%	0,0%
DivAct=0	*0,0%*	*48,2%*	*0,0%*	*0,0%*	*15,0%*	*0,0%*

Source: Silva (2008)

It is clear that the vast majority of the population of the study region lives within good accessibility conditions by all three transport modes (see table 1). The car provides high accessibility levels for all inhabitants while public transport provides high accessibility for more than 4/5th of the population. Less than one quarter of the regional population lives in medium and low accessibility conditions. Although almost 78% of inhabitants share high accessibility levels by foot, this privileged part of the population lives in restricted areas, representing around 40% of the region. Only one quarter of the residents live within maximum local accessibility conditions (having access to all considered activities at walking distance). These people share around 7% of the study region located in the core municipality and southern Matosinhos and northern Vila Nova de Gaia (see figure 6).



Source: Silva (2008)

Figure 6. Diversity of Activities accessible by non-motorized modes and public transport

The diversity of activity index by non-motorized modes provides a clear picture of the urban centres' structure of the study region. Urban centres of different levels are clearly highlighted by the geographical representation of this indicator. This outline of the main urban centres seems to be strongly related to traditional urban agglomerations along the main national road network (excluding motorways). While to the north these agglomerations are closer together forming urban corridors instead of centres, urban development has been more disperse to the south enabling a clearer recognition of boundaries of each urban centre.

Less than 22% of the population of the study area lives in areas presenting medium accessibility levels, being unable to walk to several every-day activities. The remaining 1% of population living in conditions of low non-motorized accessibility is scattered on an area representing 8% of the study region. In average the region presents a diversity of activity index of 0.91 (accessibility class A).

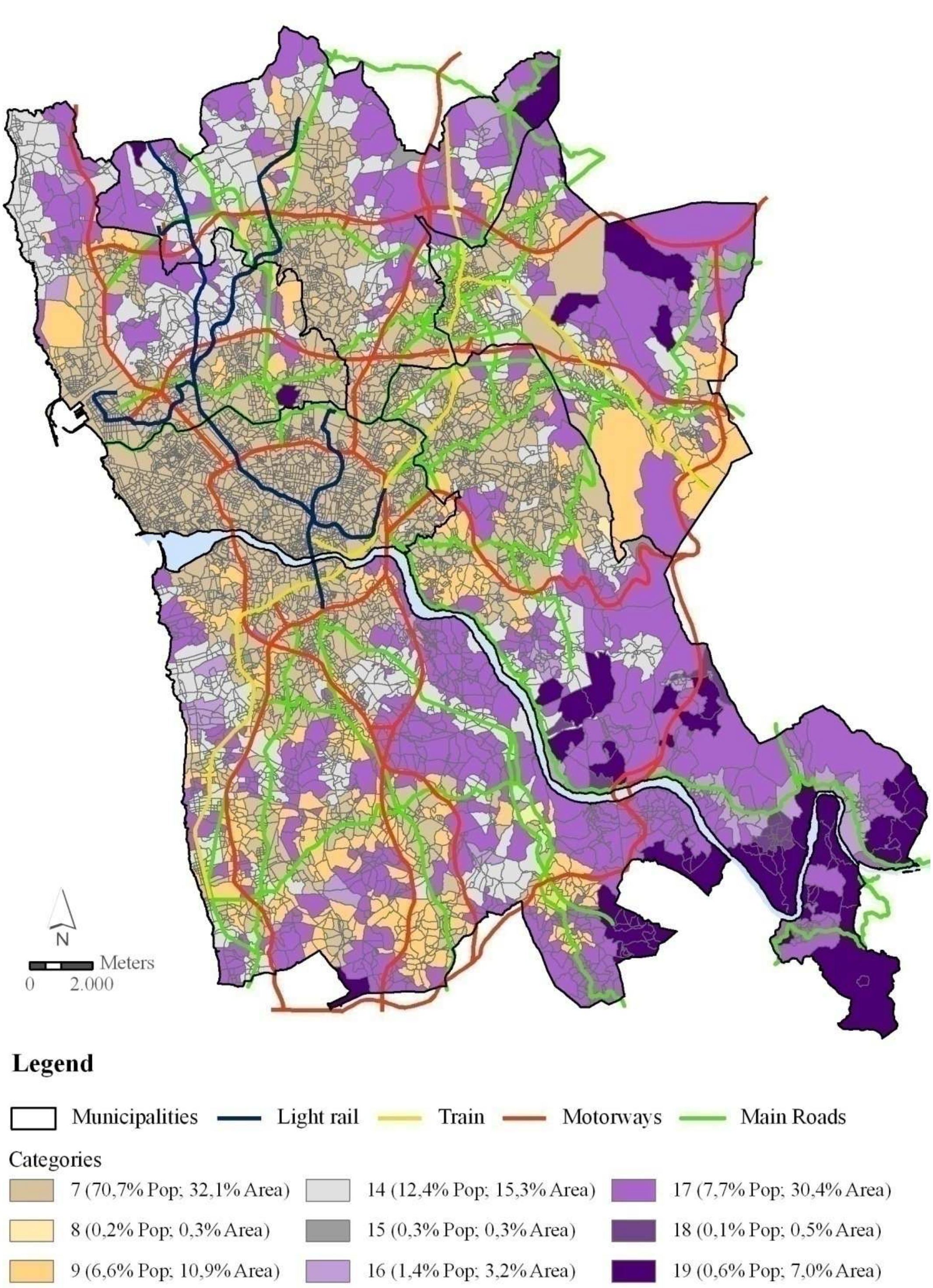
Figure 6 also presents the geographical distribution of accessibility levels by public transport modes (including public and private operators). This measure clearly marks the spatial distribution of public transport availability, with almost half of the study region area having no access to public transport service. However, although a very large area has no access to public transport service, it only holds 15% of the overall population. The vast majority of the remaining 85% of the population lives in areas with high levels of accessibility to diversity of activities by public transport (83%). 71% live in conditions of maximum accessibility to activities by public transport. Only 2% of the population lives in medium accessibility conditions by public transport in 4% of the study area. On average, the region presents an accessibility index of 0.84 (accessibility class B but very close to class A).

For the public transport the diversity of activity index gives us a representation of spatial distribution of public transport network as well as of public transport service level and activity density around public transport access points.

Considering the recent changes in the public transport network and service level (with the construction of the light rail system and reformulation of the public road operator), introducing a network effect-based service (in opposition to the traditional door-to-door service), it is natural to find the highest accessibility levels around these operators.

With regard to car accessibility, almost the entire study area provides their inhabitants with accessibility to all activity types (98% of the population living in 87% of the study area). The whole study region presents high accessibility levels providing good conditions to the entire population for the use of the car as access mode for everyday activities. On average, the study region presents almost the maximum accessibility level, with a value of 0.99 regarding activities accessible by car.

Figure 7 represents the comparative accessibility index or category, resulting from the comparison of mode accessibility. This map illustrates the land use and transport conditions constraining the higher or lower sustainability of mobility. In other words, it represents the sustainability of potential mobility. As car accessibility was found to be high (class A) for the entire study region, only 9 of the accessibility categories defined by the benchmarking cube can be found. Consequently only 4 of 9 accessibility clusters are attainable in these conditions – cluster III, non-motorized, public transport and car favouring conditions (represented in brown), cluster IV, non-motorized and car favouring conditions (represented in different shades of orange), cluster VI public transport and car favouring conditions (represented in different shades of grey) and cluster VII, car favouring conditions (represented in different shades of lilac).



Source: Silva (2008)

Figure 7. Categories and clusters of accessibility

The clear majority of the population lives under land use and transport conditions providing high accessibility by all transport modes (category 7; 71% of population), in an area smaller than 33% of the study region. The most frequent accessibility categories provided by land use and transport conditions are categories 7, 9, 14 and 17. Categories 9, 14 and 17 are present in almost 60% of the study region, defining accessibility conditions of nearly 27% of the regional population. Remaining accessibility categories have a residual importance in the study area.

Table 2. Clusters by area and population

	Clusters				Total
	III	IV	VI	VII	
Area km^2	181	63	87	231	562
%	*32,1%*	*11,3%*	*15,5%*	*41,0%*	*100,0%*
Population	769691	74327	137892	107208	1089118
%	*70,7%*	*6,8%*	*12,7%*	*9,8%*	*100,0%*

Data Source: Silva (2008)

Table 2 shows around 70% of the population living in areas providing land use and transport conditions favouring all transport modes (cluster III) while the remaining population mainly live in public transport and car favouring conditions (cluster VI). Around 7% of the population live in non-motorized and car favouring conditions (cluster IV) and almost 10% live in car favouring conditions (cluster VII).

The map clearly shows areas of the study region providing land use and transport conditions which enable travel behaviour to be sustainable – areas in cluster III, IV and VI – although real travel patterns may still have low levels of sustainability since car use is an available mode choice (there is almost no constrain to car use besides moderate congestion in a small central area). The remaining region does not provide the necessary land use and transport conditions to foster sustainable travel behaviour. Even if inhabitants would be willing to pursue more sustainable travel behaviour land use and transport conditions would disable them from doing so (without loss of quality of life).

In general, the study region falls into category 8 of accessibility to diversity of activities, resulting from accessibility class A for non-motorized modes (NM_RDivAct=0.91) and for the car (CAR_RDivAct=0.99) and from accessibility class B for public transport (PT_RDivAct=0.84). This places the study region as a whole in accessibility cluster IV, with land use and transport systems providing non-motorized and car favouring conditions.

Summarizing, the region clearly has two distinct areas with regard to land use and transport conditions for sustainable travel behaviour. Nevertheless, on average, it is fair to say that the region provides already good conditions for the use of both non-motorized modes and the car, although conditions for car use are considerably better than for walking. On the other hand public transport accessibility is still not at acceptable levels and considerably lower than car accessibility, offering a clear advantage for car use and therefore for non-sustainable travel behaviour.

3.3 Policy recommendations

The development of policy recommendations for the Greater Oporto followed two main steps: first, the definition of a general strategy for the entire study region, and second, the development of a more detailed strategy for groups of sub-regions in similar conditions. Each of these steps were based on the analysis results of the SAL, the accessibility and sustainability measures and further complementary information (such as population density maps, real travel patterns, existing land use and/or transport plans, etc). The SAL supported the design of integrated policies by serving as a framework for the selection of objectives (for policy formulation) and for the selection of policy actions to bring about the chosen objectives. Policy choice was supported by the ability of the SAL to test outcomes of different policy scenarios.

Strategies were based on four main aspects: first, time range; second, choice of the general objective on the benchmarking cube (choice of the desired accessibility category for the time range horizon); third, definition of the general path on the benchmarking cube (strategy for the general evolution of accessibility categories, from the current to the desired status); and fourth, general strategy for the urban structure (e.g. choosing between homogenizing and differentiating strategies for urban occupation). Although this last aspect is solely defined for the general strategy level, it has a strong influence on the detailed strategy level.

Table 3 summarizes the general strategy for the study region. It was reasonable to consider the use of a 10 year time horizon for the development of an integrated strategy plan focussing on land use and transport measures. Indeed, in Portugal, most land use plans are prepared for a 10 year span.

Table 3. Summary of the general strategy

Aspect	**Choice**
Time range	10 years
Objective on cube	Category 7
Path on cube	From category 8 to 7 (increase accessibility by PT)
Urban Structure	Decentralized concentration

Considering the average accessibility category of the study area – category 8 – it was considered realistic to aim to reach category 7 in the time range. This would create favourable land use and transport conditions for the use of all transport modes providing a potential for sustainability gains. More ambitious objectives, such as category 6, are almost impossible to foresee in the near future, especially in the absence of a strong social and political will to change travel behaviour towards higher sustainability.

The general path on the cube envisages a clear increase of public transport accessibility in the region which actually is the transport mode providing worst conditions. Furthermore, it seems necessary to further improve walking accessibility as well as to define the first steps of a long range strategy for car use control. This involves a shift of the study region’s position in the cube slightly down and to the front and, considerably, to the right.

Bearing in mind the size of the study area and the heterogeneity of locally available activities it is unreasonable to expect a homogenization of accessibility levels. On the other hand, the decentralized concentration seems to be a sound strategy to enhance general accessibility levels in the area. It will enable the concentration of population and activities in limited areas providing, in addition, an interesting urban system for the development of efficient and economically sound public transport systems. The general idea is to promote the development of an urban structure based on a network of urban centres supported by a network of major public transport routes. In current urban structure conditions, the strategy proposed for the GO involves the reinforcement of the main urban centralities, inverting recent trends of dispersed decentralization and urban sprawl.

Figure 8 presents a schematic representation of the proposed urban structure, highlighting several levels of urban centralities as well as the main public transport structure. The existing urban structure was identified based on the non-motorized diversity of activity index map, specifically, on class A accessibility level (high accessibility). 1st level urban centres provide walking accessibility to all activities considered (DicAct=1) while 2nd and 3rd level urban centres provide slightly lower accessibility conditions (DivAct = [0.9;1[and DivAct = [0.85;0.9[, respectively). The urban structure proposed in Figure 7 also defines new centralities; one for Gondomar and another for Matosinhos and Maia along the existing light rail corridor. These new centralities are marked in grey. The former was defined to cope with the lack of centralities in the south-eastern part of Gondomar which would seriously compromise an efficient public transport system based on a network of urban centralities. The latter aims to take advantage of an important (and highly sustainable) existing transport facility.

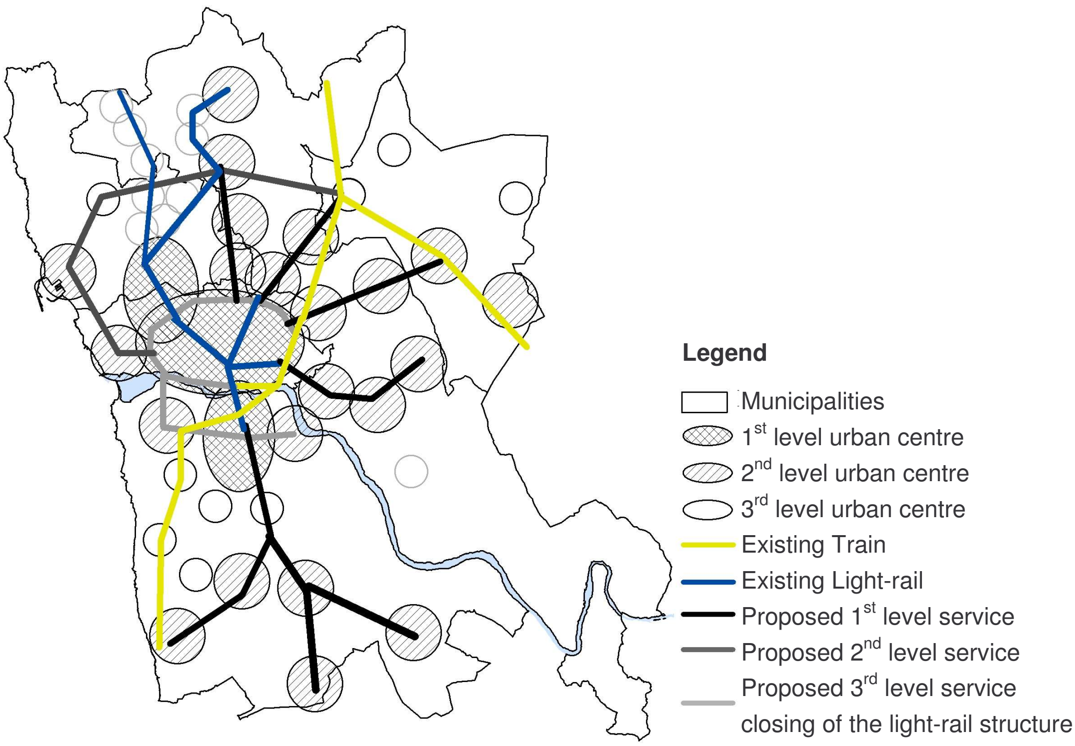


Figure 8. Proposed urban structure for the general strategy for the Greater Oporto

The general structure for the public transport system was defined in accordance to the proposed structure of urban centres. The first level public transport connects the second level urban centres to the main centre of the region (through major public transport interchanges located at strategic points of the public transport network of the main centre). The second level public transport connects a selected number of second level urban centres between each other while the third level works as local public transport access.

With regard to the main public transport structure, figure 8 presents the backbone for the proposed regional public transport system, including some of the existing subsystems. The first level public transport service is proposed along the main corridors of urban centres to the north of the main centre and with a more complex structure to the south (opening branches towards the south of Vila Nova de Gaia and connecting these centres to the light rail network). In combination with the existing rail and light-rail system, these new first level routes form the main radial system of the region. One major circular route is proposed connecting Maia and Matosinhos to answer the strong interdependency between these two municipalities. This route can be extended eastward from Maia to Valongo (more specifically Ermesinde, holding a major rail station where rail routes to the north diverge), and southward from Matosinhos to Oporto. This circular system would work as an extension of the rail route coming from the east, ending at an inner circular route of the light rail (third level system).

One additional circular route for the light rail network system is proposed. This route belongs to the urban network of the major urban centre and rings the municipality of Oporto. This route ties the second level transport network to the urban centre network (light rail and bus) by providing an increase in choice for travel to the main centre. Furthermore it ties the second level transport network together and to a larger regional transport service providing a public transport service which is tailored to encompass some of the complexities of current travel patterns. The provision of real network-based public transport service is essential for the preparation of car use restriction strategies.

Summarizing, to achieve the desired accessibility levels (cluster III) the general strategy envisages the development of a transit oriented urban structure at the regional scale. This large scale urban structure is based on high accessibility levels at local level for a limited number of urban centres. These urban centres work as preferential locations for population and activities. Urban development outside urban centres is to be discouraged. With regard to public transport, a general structure is proposed aiming to provide sustainable medium distance travel which enables sustainable access to all activities (especially non-local activities) by enabling a variety of travel patterns. Additionally there is a requirement for a larger range of public transport and better service levels of the existing service.

The detailed strategy for groups of sub-regions was defined based on the outlined strategy for the entire study region. Figure 9 presents the division of the study region into strategy groups. Ten different groups were defined based on their accessibility conditions and occupation. Table 4 summarizes the detailed strategy for each of the ten groups defined in figure 9.

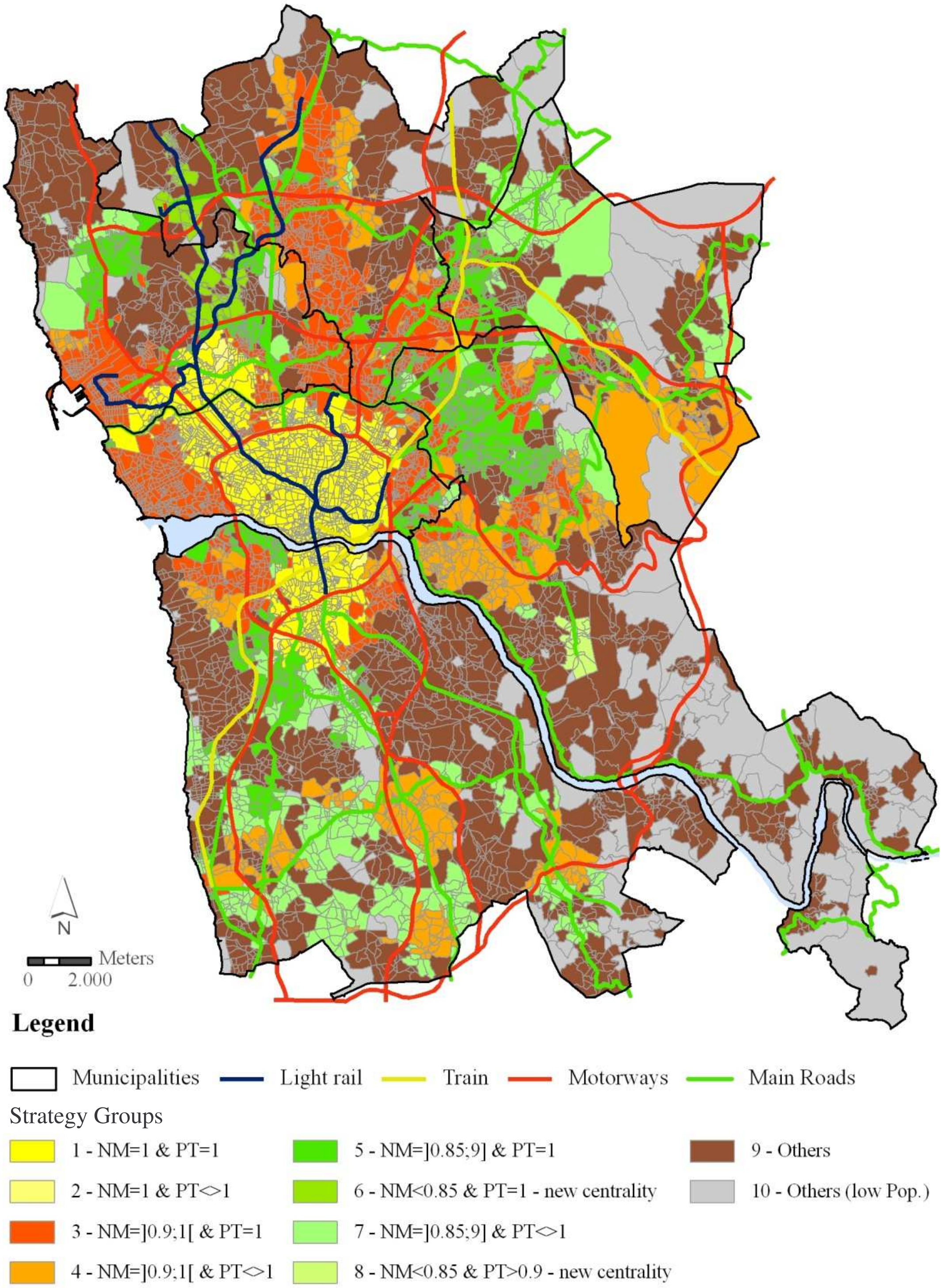


Figure 9. Strategy mapping

Source: Silva (2008)

Table 4. Summary of strategy and action for each strategy group

Group	OBJECTIVE				PATH				Urban Centres	ACTIONS	
	Category	Class			Category	Class				Main	Detail
		NM	PT	CAR		NM	PT	CAR			
1	7	A	A	A	7→7	-	-	A ↓A	1st level	1 4	1.1 4.1
2	7	A	A	A	7/9→7	-	A ↑A C→A	A ↓A	1st level	1 2 4	1.1 2.3.2 4.1
3	7	A	A	A	7→7	A ↑A	-	A ↓A	2nd level	1 3 4	1.1 3.2 4.2
4	7	A	A	A	7/8/9→7	A ↑A	A ↑A B→A C→A	A ↓A	2nd level	1 2 3 4	1.1 2.1/2.2 3.2 4.2
5	7	A	A	A	7(5) →7	A ↑A	-	A ↓A	3rd level	1 3 4	1.1 3.3 4.3
6	7	A	A	A	14→7	B→A	-	A ↓A	3rd level	1 3 4	1.1 3.3 4.3
7	7	A	A	A	7/8/9(5) →7	A ↑A	A ↑A B→A C→A	A ↓A	3rd level	1 2 3 4	1.1 2.3.1 3.3 4.3
8	7	A	A	A	14→7	B→A	A ↑A	A ↓A	3rd level	1 2 3 4	1.1 2.3.1 3.3 4.3
9	14/15	B/C	A	A	14/16/17(20-23) →14 15/18/19(24-27) →15	-	A ↑A B→A C→A	-	Remaining region	2	2.3.3/2.4
10	-	-	-	-		-	-	-	rural	1	1.2

Source: Silva (2008)

With regard to actions, these were chosen to bring about changes to four main aspects: urban occupation or population density (1), public transport network and service (2), distribution and diversity of activities (3), and, car use convenience (4). These main actions are then further detailed in the last column[i].

The first group, providing accessibility to all activity types by public transport and walking, encompasses the best conditions for sustainable mobility in the study region. Further urban development and population density should be encouraged in these sub-regions. Additionally, considering the availability of viable alternatives, car use should be discouraged and even hindered through the reduction of car infrastructure capacity. The second group, should follow a similar strategy to the one defined for the first group adding public transport service improvement, in order to provide accessibility to all activity types by this mode. Public transport improvements should centre on the expansion of the network as well as on increasing frequency of the existing network (even if at the expense of door-to-door service). The third group should follow a similar strategy to the one defined for the first group, adding possible improvements to local accessibility levels. Being a second level urban centrality, not all activity types must be at walking distance. Therefore a more detailed survey of lacking activities (provided by the SAL) as well as the assessment of the need for these activities at walking distance (which is a local decision) is required. This information can then be used to detail the activity types which should be encouraged (if any) as well as their preferred location. Furthermore, car use restriction should also be more limited than for first level urban areas with measures mainly centred on travel price.

The fourth group should follow a similar strategy to the one defined for the third group adding the improvement of public transport service. The improvement for second level urban centralities, involves the development or reinforcement of the first and second level public transport structure (improving frequencies and speed while providing direct service between centres). The fifth group should follow a similar strategy to the one defined for the third group but with lower expectations on locally accessible activities, regarding that third level centres are involved (see action 3.3). Furthermore, car use restrictions should also be more limited than for second level urban areas with measures mainly centred on traffic calming. The seventh group adds public transport accessibility concerns to the general strategy of the fifth group. Considering the level of the urban centre, public transport strategy should focus on the direct access to higher level urban centres providing access to lacking activities. The sixth and eighth strategy groups should follow the general strategy of the fifth and seventh group, respectively. Aiming at the development of new third level urban centres, special attention is required for the development of strategies attracting new activities, as well as on the activity types required. The ninth strategy group should act solely upon the public transport aiming to provide a viable alternative to the car (which is currently the only viable transport mode). These sub-regions require an effective alternative transport offering access to the nearest urban centre providing most activities and also access to higher level transport service. This requires door-to-door public transport systems or even ‘on demand’ transport services. Giving the low density of urban occupation in these areas it is unreasonable to strive for high levels of walking accessibility. The tenth strategy group is characterized by very low density of occupation (less than 150inh/km^2) therefore, excluding viability of public transport measures. As a result no aim is defined for these rural sub-regions, were action should centre on disabling any further occupation (or even reversing any prior urban development).

4 Conclusions: accessibility and urban policies

Generally speaking, accessibility has been disregarded in urban planning in spite of the widespread recognition of its importance to urban living. Local planning departments tend to overestimate the role of mobility attached to economic growth objectives in detriment of softer measures designed to increase the general accessibility levels within an urban region.

This paper aimed to illustrate the role of the accessibility concept for urban policy formulation in the context of sustainable development. The research involved the use of an accessibility-based tool – the Structural Accessibility Layer (SAL) – in the design of integrated land use and transport policies. The SAL shed light on structural accessibility patterns and enabled, as well as supported, the definition of a range urban mobility policies tailored to the Greater Oporto case. In this sense, the concept of structural accessibility was found to be a useful tool to bridge the gap between land use and transport planning.

Finally, the application of SAL to Greater Oporto shows that only 10% of the resident population has no viable alternative to car use. However, the current modal split in this region shows that more than 50% of trips are being made by car. These results suggest two things: first there seems to be a need for push instead of pull land use and transport measures (i.e. to disable car use instead of simply enable sustainable alternatives); and second there seems to be a need for policy measures on complementary field (influencing for instance lifestyles) in the absence of urban structure push measures. Indeed, with regard to the influence of urban structure on mobility, this research shows that sustainable land use and transport conditions have but modest influence on sustainable travel behaviour.

References

Banister, D (1994a) *Transport Planning*, E&FN Spon. London.

Banister, D (1994b) “Reducing the need to travel through planning”, *Town Planning Reviews* **65**(4) 349-354.

Bertolini, L, Clercq, F and Kapoen, L (2005) “Sustainable accessibility: a conceptual framework to integrate transport and land use plan-making. Two test-applications in the Netherlands and a reflection on the way forward”, *Transport Policy* **12**(3) 207-220.

Cervero, R (2003) “Growing smart by linking transportation and land use: perspectives from California”, *Built Environment* **29**(1) 66-78.

Geurs, K and Wee, B (2004) “Accessibility evaluation of land-use and transport strategies: review and research directions”, *Journal of Transport Geography* **12** 127–140.

Halden, D (2002) “Using accessibility measures to integrate land use and transport policy in Edinburgh and the Lothians”, *Transport Policy* **9** 313–324.

Halden, D, McGuigan, D, Nisbet, A and McKinnon, A (2000) *Accessibility: Review of measuring techniques and their application,* Scottish Executive, Edinburgh.

Handy, S and Niemeier D (1997) “Measuring accessibility: an exploration of issues and alternatives”, *Environment and Planning A* **29**(7) 1175-1194.

INE (1991) *Recenseamento Geral da População 1991,* INE. Lisboa.

INE (2000) *Inquérito à Mobilidade da População Residente 2000,* INE. Lisboa.

INE (2001) *Recenseamento Geral da População 2001,* INE. Lisboa.

ISIS (1999) *Outline of Concept. Deliverable 1 of the European Project TRANSLAND,* European Commission.

NEA (2003) *Integration and Regulatory Structures in Public Transport. Final Report,* European Commission DG TREN.

Rodenburg, C, Ubbles, B and Nijkamp, P (2002) “Policy scenarios for achieving sustainable transport in Europe”, *Transport Reviews* **22**(4) 229-472.

Silva C (2008) *Comparative Accessibility for Mobility Management – The Structural Accessibility Layer*, PhD Thesis by the Faculty of Engineering of the Oporto University, Oporto.

Stead, D (2003) “Transport and land-use planning policy: really joint up?” *International Social Science Journal* **55**(2) 333-347.

Stead, D, Geerlings, H and Meijers, E (2003) *Integrated land use planning, transport and environmental policy-making: an international comparison,* NOVEM, Utrecht.

Straatemeier, T (2006) “Accessibility: an interesting concept to address strategic planning issues in the Amsterdam region?” *AMIDSt: Transportation Planning a Policy Design Challenge*, Amsterdam.

Straatemeier, T and Bertolini, L (2008) “Joint Accessibility Design: a framework developed for and with practitioners to stimulate the integration of regional land-use and transport strategies in the Netherlands”, *TRB 2008.* Washington D.C.

Wegner, M and Fürst, F (1999) *Land-Use Transport Interaction: State of the art. Deliverable 2a of the European Project TRANSLAND,* European Commission.

i Action types considered:

1 Act upon urban occupation (population density):

1.1 Action stimulating occupation (increasing population density);

1.2 Action restricting occupation (maintaining or even decreasing population density);

2 Act upon public transport service:

2.1 Develop a 1st level network providing direct and fast access of 2nd level centralities to the main urban centre (service characteristics: high frequency, speed and capacity, few stops; favoured mode: train, light rail or segregated bus routes);

2.2 Develop a 2nd level network providing direct and fast access between the main 2nd level centres (service characteristics: high frequency, speed and capacity, few stops; favoured mode: light rail, segregated or not segregated bus routes);

2.3 Develop a 3rd level network

2.3.1 Providing direct access from a 3rd level centre to the most convenient higher level centre (service characteristics: low frequency, few stops, medium capacity; favoured mode: bus);

2.3.2 Providing frequent and wide ranging access between larger urban centres (service characteristics: high frequency and reliability, network service in opposition to a door-to-door network; favoured mode: light rail and segregated or not segregated bus);

2.3.3 Providing interurban access to the most convenient centre (service characteristics: radial, low frequency, many stops, door-to-door network, medium to low capacity; favoured mode: bus);

2.4 Develop a 4th level network providing local access in low population density (service characteristics: time table based or on-demand frequency, low capacity, many stops, door-to-door network; favoured mode: small busses, vans or taxis);

3 Act upon activity diversity (in connection with urban centre level)

3.1 Providing local access to all activity types in the 1st level urban centres; Aim NMDivAct=1

3.2 Providing local access to almost every activity type in 2nd level centres; it is reasonable that activity types such as universities (3), cinema (6) and theatre (7) are not present at this centralities (at least not the guarantee of access for all its population); aim NMDivAct>0.95

3.3 Providing local access to most relevant activity types in 3rd level centres; it is reasonable that activity types such as universities (3), cinema (6) theatre (7), other leisure activities (9), non-food shopping (11), hospital and clinics (13), postal office (15) and other activities (17) are not present at this centralities (at least not the guarantee of access for all its population); aim NMDivAct>0.85.

4 Act upon car use restriction (in connection with urban centre level)

4.1 Reduce capacity of road network (for instance, reduce parking spaces, reduce width of roads and number of lanes) – indicated for 1st level urban centres;

4.2 Increase travel price (for instance increase parking prices) – indicated for 2nd level urban centres;

4.3 Traffic calming measures (such as the reduction of maximum travel speed, the use of roundabouts) – indicated for 3rd level urban centres.